The Victorian Naturalist

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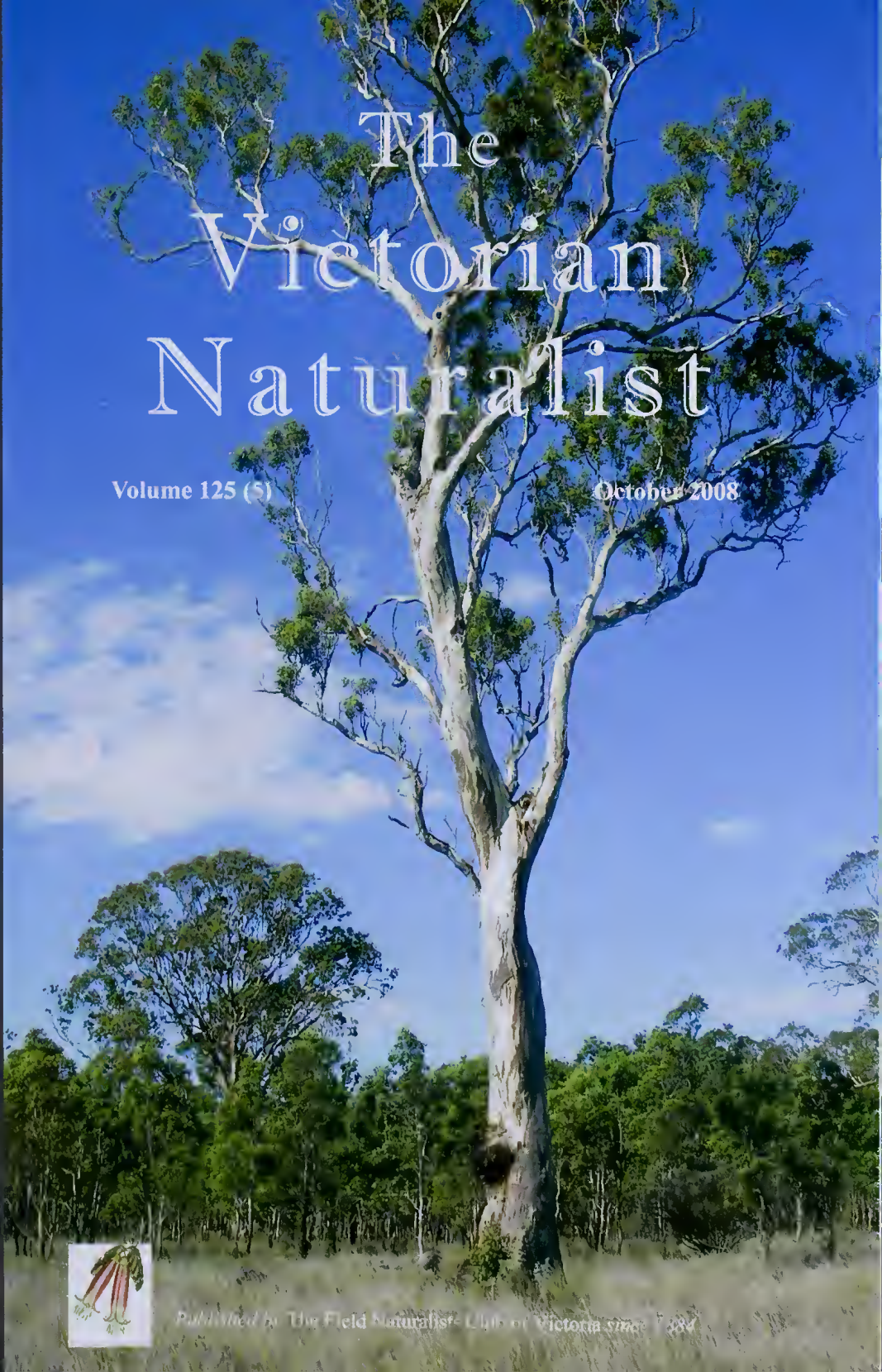

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From the Editors

This issue of *The Victorian Naturalist* publishes the results of recent work, in the form of a Research Report and two Contributions. In this instance there is no concentration in geographic area, flora or fauna. These papers help to maintain one of our aims for the journal, to be both informative and diverse in its contents.

As part of our charter of keeping our readers informed about natural history, reviews of recently published works in this field have an integral place in our journal. Such is the volume of publishing, and the regularity with which this output arrives in our mailbox, that we could easily devote most of each issue to reviews! However, in this particular issue no space for reviews was available.

Like this one, recent issues of the journal have been 32 page in length, the advantage of this form being that it is the most cost-effective way to maintain a proper ratio of papers to reviews and still have colour where required. However, this does nothing to reduce the backlog of reviews that are ready to be published.

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The distribution of the Southern Brown Bandicoot *Isoodon obesulus* in south central Victoria

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Abstract
The Southern Brown Bandicoot *Isoodon obesulus* has declined dramatically in both range and abundance since European Settlement. The species' distribution is largely determined by the availability of the dense, heathy vegetation that formed on the sandy coastal plains of south-eastern Australia. One of the five major areas of habitat in Victoria occurred in the Port Phillip-Western Port-West Gippsland region of Victoria. This 'south central' region is one of the most populated and developed regions in Australia, and habitat suitable for Southern Brown Bandicoots has become rare, highly fragmented and influenced by a range of potentially threatening processes. We looked at the historic and current distribution of Southern Brown Bandicoots in the south central region to identify options for conservation management of the species. We found evidence that populations in the Greater Melbourne area, including the Mornington Peninsula, had declined substantially in recent decades. The species is now uncommon in administratively secure conservation reserves in the region apart from the Royal Botanic Gardens Cranbourne, where recent management initiatives appear to have been effective in controlling some known threats. Surprisingly, an extensive population also persists on predominantly agricultural and utility land north of Western Port Bay, around the former 'Great' (Koo-wee-rup) Swamp where they live close to humans, livestock and domestic pets. This population faces a number of immediate threats, yet may be crucial to the long term viability of the species in the south central region. Effective management of the Koo-wee-rup population will require innovative measures to mitigate threats across a range of land uses and tenures. (*The Victorian Naturalist* **125** (5), 2008, 128-139).

Introduction

The Southern Brown Bandicoot *Isoodon obesulus* is a small terrestrial marsupial that was reportedly common and widespread at the time Europeans settled in south-eastern Australia (Gould 1845; Krefft 1865, both cited in Lunney and Leary 1988). Although the species has been recorded at a variety of locations from the central coast of NSW to the Mt Lofty Ranges in South Australia, the majority of records come from sites within 50 km of the Victorian coastline (Opie *et al.* 1990; Menkhorst and Seebeck 1995). In both NSW and South Australia the range of the species has contracted dramatically and it now appears to be restricted to just a few isolated regions in each state (Department of Environment and Conservation 2005; South Australian Department of Environ-ment and Heritage 2005). The taxon is currently listed as endangered under the federal *Environment Protection and Biodiversity Conservation (EPBC) Act* 1999. It is also listed as endangered in New South Wales (*Threatened Species Conservation Act* 1995) and as vulnerable in South Australia (*National Parks and Wildlife Service Act* 1972). Because of the perceived vulnerability of the remaining populations, draft recovery plans have recently been developed for the species, covering its entire mainland distribution (Department of Environment and Conservation 2005; South Australian Department of Environment and Heritage 2005). However, despite evidence of ongoing decline throughout its range, and uncertainty about the current status of known populations, the species has been considered by some authorities to be relatively secure in Victoria (Scientific Advisory Committee Flora and Fauna Guarantee 1991; Menkhorst and Seebeck 1995a; DSE 2007).

Southern Brown Bandicoots have a disjunct distribution across southern Victoria (Fig.1). Most records are clustered within parts of the East Gippsland Lowland, Gippsland Plain (Western section), Otway Plain (Anglesea section), Warrnambool Plain (Port Campbell section), Greater

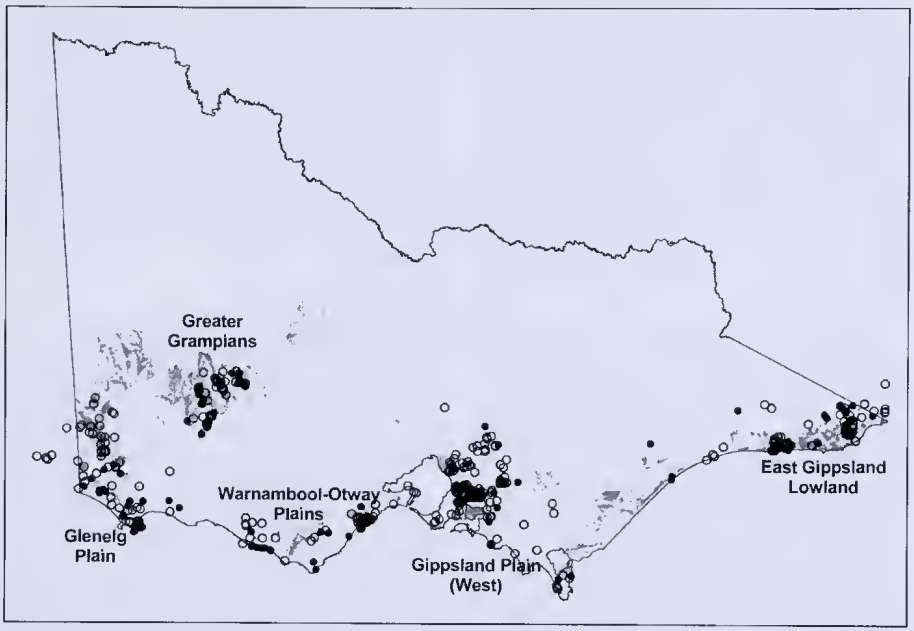

Fig. 1. Distribution of the Southern Brown Bandicoot in Victoria. Open circles indicate records from the Atlas of Victorian Wildlife before 1991; filled circles indicate records from 1991 to 2007. Grey areas represent historic extent of Heathy Woodland, Sand Heathland, Sand Heathland/Wet Heathland Mosaic and Banksia Woodland EVCs derived from pre-1750 vegetation maps (DSE 2006).

Grampians and Glenelg Plain Bioregions (NRE 1997). The species is also known from Wilson's Promontory and the Yarra Ranges, with scattered records elsewhere in the state. Records typically come from sites that support heathlands, heathy woodlands and forests, sedgelands or shrublands that occur on sandy, well-drained soils (Opie *et al.* 1990; Menkhorst and Seebeck 1995; Fig.1). The species has also occasionally been recorded further inland in riparian woodlands, scrubs and grasslands (Menkhorst and Seebeck 1995a). In East Gippsland bandicoots most commonly occur in Ecological Vegetation Classes (EVCs) such as Lowland Forest or Banksia Woodland that are analogous to the heathy woodlands found elsewhere in the state. In several regions, large areas of potential habitat occur within major National Parks or other secure reserves, providing some confidence in the long-term viability of the species at a State level (Menkhorst and Seebeck 1990, 1995a). However, within the Gippsland Plains Bioregion, particularly the western section spanning the region between Port Phillip Bay and Cape Liptrap, there are few if any large continuous tracts of habitat capable of supporting large populations of Southern Brown Bandicoots (NRE 1997). This area, subsequently referred to as south central Victoria, is the most populated region of Victoria:and extensive land clearance for agriculture and urban development has seen the loss or fragmentation of most areas of habitat suitable for Southern Brown Bandicoots. The remaining patches of indigenous vegetation probably only support small, isolated populations that are potentially highly vulnerable to extinction (e.g. Reed 2004). As a consequence. Southern Brown Bandicoot populations may be at greater risk of decline in south central Victoria than in other regions of Victoria.

Bandicoots were reportedly '...common throughout the whole bush' around Melbourne and the Mornington Peninsula in the 1800s (Wheelwright 1862). By the later half of the 20th century, wildlife experts were warning of the apparently inevitable and ongoing decline of Southern Brown Bandicoots in the region (e.g. Dixon 1966; Seebeck 1977). These pes-

simistic predictions were due in part to recognition of the likely impacts of suburban expansion on remnant bandicoot populations. Urbanisation often leads to dramatic loss and modification of habitat and results in high densities of introduced predators, high road mortality, changed fire regimes, habitat fragmentation and subsequent isolation of populations, all of which are identified as major threats to the species (Department of Environment and Conservation 2005).

Southern Brown Bandicoots were known to persist at some sites in the Greater Melbourne region until relatively recently (Atlas of Victorian Wildlife; Brereton *et al.* 2004; Hans Brunner pers. comm.; Jeff Smith pers. comm.) but anecdotal evidence indicates that most, if not all, of these populations have now disappeared. This mirrors a familiar pattern of population isolation, decline and local extinction that has occurred throughout the species' range in south-eastern Australia (Paull 1995; Department of Environment and Conservation 2005). There is a clear risk that populations that remain in the south central region of Victoria will also continue to decline unless threats are effectively managed.

Despite its wide geographic distribution, the factors that determine the suitability of habitat and the causes of decline of Southern Brown Bandicoot populations are poorly understood (Opie *et al.* 1990; Braithwaite 1995). The species is now curiously rare in many less developed regions, including some with extensive areas of potentially suitable habitat secured within conservation reserves (Opie *et al.* 1990; Menkhorst and Seebeck 1995; Paull 1995; TSSC 2001; Coates and Wright 2003; Robley and Wright 2003; Andrew Murray pers. comm.). Paradoxically, Southern Brown Bandicoot populations occasionally persist in highly modified landscapes near urban settlements where they presumably face high levels of threat (Department of Environment and Conservation 2005; South Australian Department of Environment and Heritage 2005; pers. obs). Given the somewhat enigmatic nature of bandicoot distribution it is difficult to predict the location of bandicoot populations in the fragmented landscape remaining in south central Victoria. However, the ongoing decline and potential vulnerability of populations demands an assessment of the current status of the species in the region. This paper attempts to increase knowledge pertaining to the current distribution and status of Southern Brown Bandicoot in south central Victoria and to inform management of the remaining populations.

Methods

South Central Study Area

The study area comprises the western section of the Gippsland Plains Bioregion (NRE 1997, Fig. 2), extending east from the city of Melbourne to Drouin and south to Cape Liptrap. The area includes the eastern and south-eastern Suburbs of Melbourne, the Mornington Peninsula and Western port Bay (including French and Phillip Islands) and extends along the Bass Coast from San Remo to Walkerville. Although some evidence suggests that Southern Brown Bandicoots may once have occurred more extensively in the eastern section of the Gippsland Plains Bioregion (Bilney *et al.* 2006), this area was excluded from the study because there were few modern records of the species (Menkhorst and Seebeck 1995a; Atlas of Victorian Wildlife). For the purposes of discussion we have arbitrarily divided the study area into seven main geographic zones. These zones are shown on Fig. 2 and comprise: (1) the south-eastern suburbs of Melbourne; (2) northern Mornington Peninsula; (3) southern Mornington Peninsula; (4) Western Port Bay area; (5) Koo Wee Rup Swamp; (6) foothills (outer swamp) and (7) Bass Coast.

Location Records

Records of Southern Brown Bandicoots within Victoria up to 2007 were extracted from the Atlas of Victorian Wildlife database by officers within the Biodiversity Branch, Department of Sustainability and Environment (DSE), Victoria. Atlas of Victorian Wildlife data is made available within DSE via the Department's Corporate Geospatial Data Library. All records classed as either 'confirmed' (identified by an experienced observer) or 'acceptable' (little or no reason to doubt

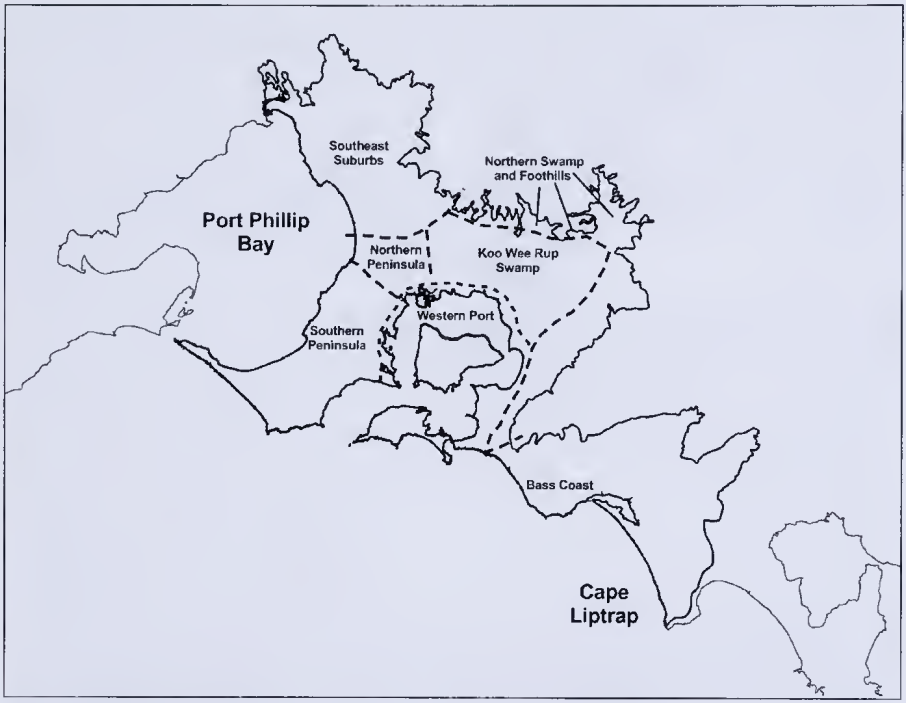

Fig. 2. Approximate location of geographic zones within the south central study area.

record) were included. Beginning 2005, additional records were compiled from road-kills, direct sightings and deliberate sign surveys by the authors, other wildlife experts, volunteers and students from Chisholm Institute of TAFE and Melbourne University. Published records of Southern Brown Bandicoots in the region were obtained from a literature search. Anecdotal observation records were solicited from the community through local councils and landcare networks and local wildlife experts.

Mapping

All of the location-specific records of Southern Brown Bandicoots in the study area were compiled and mapped using Arcview GIS 3.2 (Environmental Systems Research Institute Inc.). Location records were plotted over map layers containing extant EVCs as well as a reconstruction of the vegetation classes that were present in Victoria prior to European Settlement (DSE 2006). The reconstruction was modelled on the extant EVC information mapped at 1:100 000 with areas currently mapped as cleared being replaced by modelled and interpreted data. These plots were used to identify EVCs that showed concordance with mapped bandicoot locations. Suitable EVCs were also identified based on information contained in published literature sources and the experience of the authors. We also incorporated a map layer identifying Victorian bioregional boundaries.

Results

Bandicoots in south central Victoria

Southern Brown Bandicoots are known to have previously occupied a range of sites across the south central region of Victoria (Fig. 3). Individuals have been recorded from as far west as Arthurs Seat on the Mornington Peninsula and as far east as the Fish Creek area in South Gippsland. However, records of the species were generally less common in either the extreme west or east of the region. The majority of available records occur throughout the northern sections of the Mornington Peninsula and coastal Western Port Bay particularly in the region between Frankston and Tooradin.

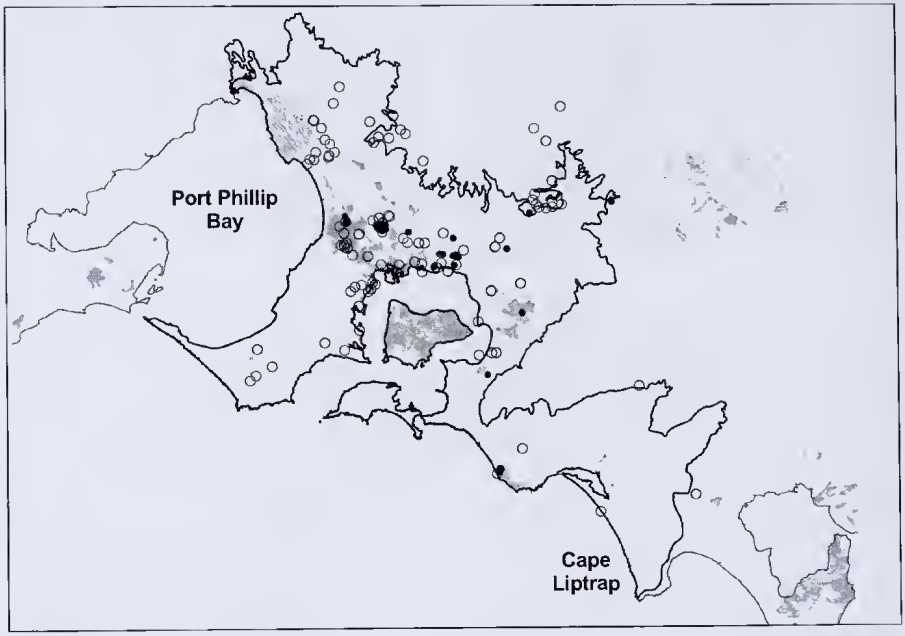

Fig. 3. Distribution of the Southern Brown Bandicoot in the south central study area. Open circles indicate records from the Atlas of Victorian Wildlife before 1991; filled circles indicate records from 1991 to 2007. Grey areas indicate historic extent of Heathy Woodland, Sand Heathland, Sand Heathland/Wet Heathland Mosaic EVCs derived from pre-1750 vegetation maps (DSE 2006).

Each of the major geographic zones within the study area is considered separately below.

South-eastern Suburbs of Melbourne

Historic records show that the Southern Brown Bandicoot was once scattered throughout the greater Melbourne region. It was known from the bayside suburbs of Melbourne and extended to the southern portions of the Mornington Peninsula. Wheelwright (1862) considered bandicoots to be common around Melbourne. Until at least the 1950s Southern Brown Bandicoots still occurred in the bayside suburbs of Sandringham, Black Rock and Beaumaris (Rayment 1954; Ward 1966). In the 1960s the species was reportedly common in some suburbs south-east of Melbourne where it occurred in 'pockets of heathland, rough pasture and market gardens' (Menkhorst and Seebeck 1990). Dixon (1966) remarked that it was '...possible to trap numbers of (southern brown) bandicoots in areas less than twenty miles (32 km) from Melbourne'. Brereton *et al.* (2004) also noted that the species was once widespread in the suburbs east and south-east of Melbourne. In the late 1980s and early 1990s bandicoots were still believed to be 'widespread' at Woodlands Golf Course in Mordialloc (Brereton *et al.* 2004) and around the same time also occurred in at least two small reserves in neighbouring Dingley and Keysborough (Atlas of Victorian Wildlife, Jeff Smith pers. comm.). The species has not been reported in any of these locations for more than 15 years.

Northern Mornington Peninsula

Southern Brown Bandicoots have been reported from many sites in the Frankston area, including a range of small council reserves and golf courses (Hans Brunner pers. comm.). However, most of the Atlas of Victorian Wildlife unpubl. records in this area occur in or around several of the largest patches of indigenous vegetation remaining in the Frankston, Langwarrin, Cranbourne and Tyabb areas, partly reflecting the natural distribution of heathy

woodland vegetation communities (Fig. 3). These remnants include secure conservation reserves such as The Royal Botanic Gardens Cranbourne (RBGC), the Pines Flora and Fauna Reserve in Frankston North and the Langwarrin Flora and Fauna Reserve. The RBGC is known to still support a relatively dense population of Southern Brown Bandicoots (Coates and Wright 2003; Stava 2005; RBGC unpublished data) but populations at the other sites appear to have generally declined. Bandicoots or their signs were once common at the Pines Flora and Fauna Reserve (Armstrong *et al* 1990; Norris and Associates 1993 Kimber 1997; Taylor 1999; Hans Brunner unpubl.) but it now appears that the population at the site has declined dramatically in recent decades (Hans Brunner pers. comm. TC and DN unpubl.). A 'good' population was also known to occur in and around the nearby Langwarrin Flora and Fauna Reserve until the 1980s (Atlas of Victorian Wildlife; Andrew *et al.* 1984; Brereton *et al.* 2004) but the species has not been recorded at the site for many years (Atlas of Victorian Wildlife; Leon Costermans pers. comm.).

Southern Mornington Peninsula

Three Southern Brown Bandicoots were trapped at two sites southwest of Arthurs Seat in the early 1970s (Callanan and Gibson 1977). They were also known anecdotally from a variety of locations between Mt Martha and Greens Bush (Hans Brunner pers. comm.; Callanan and Gibson 1977). Sault (2003) noted the species had been 'fairly widespread' on the Mornington Peninsula during the later half of the 20th Century. However, documented records are actually quite uncommon in areas south-west of the Frankston-Flinders Road, including parts of the Mornington Peninsula National Park (Atlas of Victorian Wildlife; Fig. 3). No large populations have ever been identified on the southern Peninsula and no unequivocal evidence of the species has been recorded in this region since 1987, despite considerable survey effort over the last 8–10 years (Malcolm Legg pers. comm.). A single bandicoot believed to be a Southern Brown was recently reported from Point Nepean (Brett Lane pers. comm.). However, in the absence of other recent evidence it is possible that the sighting was of a juvenile Long-nosed Bandicoot *Perameles nasuta*, a species that is known to still occur at Point Nepean and in other parts of the southern peninsula (Menkhorst and Seebeck 1995; Atlas of Victorian Wildlife; Malcolm Legg pers. comm.; TC unpublished data.).

Western Port

Andrew *et al.* (1984) considered the Southern Brown Bandicoot to be 'moderately common around the (Western Port) bay'. It has been recorded at many 'heathy' sites on the Western Port coast from Sandy Point to Grantville. The species was readily trapped at Yaringa Reserve (Tyabb) prior to 1980 (Braithwaite *et al.* 1980). Indirect evidence of the species has recently been reported from nearby Hastings (Waringine Reserve) and Crib Point (Jack's Beach), where diggings and hairs were identified in late 2006 (Malcolm Legg pers. comm.; Hans Brunner pers. comm.). There were a number of historic records from coastal regions north of Western Port including the coastal villages of Cannons Creek, Warneet and Blind Bight but the most recent records from this area came from sites to the east of Tooradin, particularly the area around the lower reaches of Cardinia Creek, Deep Creek and Bunyip River. Bandicoot scats and hairs were recently collected from near the picnic area at the Lookout tower at Tooradin Swamp (Hans Brunner and Paul Bertuch pers. comm.; TC unpublished data).

Recent evidence of the species to the east of Western Port Bay is sparse and largely anecdotal. Museum specimens were collected in this region in the 1970s and several individuals were trapped on private land near Lang Lang in the mid 1990s. Anecdotal, unconfirmed reports suggest that the species may still occur near Lang-Lang (T Westwood pers. comm.), the Gurdies and Grantville (RW unpublished records). Although Southern Brown Bandicoots were reported anecdotally to be widespread on Phillip Island early last century (Kirkwood and Johnson 2006) there are no specimens or documented records of the species from any of the islands in Western Port Bay (Phillip, French and Quail Islands).

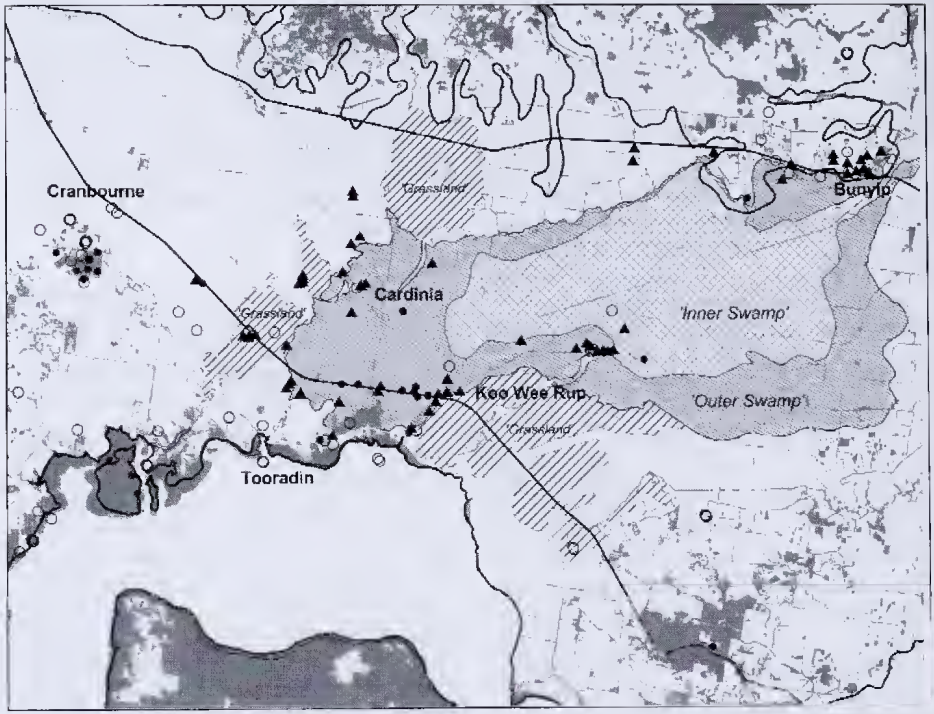

Fig. 4. Distribution of the Southern Brown Bandicoot in the Koo-Wee-Rup region. Open circles indicate historic records (1750-1990) from the Atlas of Victorian Wildlife unpubl., filled circles indicate recent records (1991-2007) from the Atlas of Victorian Wildlife unpubl. and filled triangles indicate new records collected during the present study. The figure shows the extent of remnant native vegetation (grey shading) and the historic extent of the Koo-Wee-Rup Swamp and associated grasslands from the reconstruction by Yugovic and Mitchell (2006).

Koo-Wee-Rup Swamp

Bandicoots were known from the area to the north of Western Port Bay, particularly around the (former) Koo-Wee-Rup or 'Great' swamp, as described by Yugovic and Mitchell (2006; Fig. 4). Prior to 1900, individuals were reported on Ballarto Road near Cardinia and on the South Gippsland Railway line north of Tooradin (Atlas of Victorian Wildlife unpubl.). During the 1970s individuals were also recorded from Tooradin and Bayles. There were a number of post-1990 records from sites near Clyde, Cardinia, Bayles and Koo-Wee-Rup (Atlas of Victorian Wildlife; DN/TC unpublished records). Many residents reported regular sightings of Southern Brown Bandicoots on private properties or utility corridors such as drains, roads and rail reserves. Property owners reported seeing Bandicoots in and around sheds and outbuildings or amongst gardens and hedges. Bandicoots were reported from the middle reaches of the Yallock Creek (also known as Number Four Drain) near Bayles. Bandicoots were reported from, and several presumably road-killed bandicoot carcasses were recovered from roads in the region (Julie Weatherhead, Sarah Maclagan, David Nicholls unpubl.). Interestingly, there were no major patches of remnant heathy vegetation in this region, and bandicoots appeared to survive almost entirely in small remnants or narrow strips of shrubby vegetation within an otherwise agricultural matrix.

Northern swamp and foothills (Garfield to Longwarry)

Southern Brown Bandicoots were recorded from sites immediately to the north of the (former) Koo-Wee-Rup swamp. Sightings of the species from the Bunyip area date back to before 1900 (Atlas of Victorian Wildlife unpubl.). More recently, a number

of sightings have been reported between Nar Nar Goon and Drouin, but particularly from an area between Garfield, Bunyip and Longwarry. While many of these records are technically just outside the northern boundary of the study area, they are considered to be part of a larger cluster that spans the somewhat arbitrary boundary between the Gippsland Plain and the Highlands-Southern Fall Bioregion. Historically the vegetation in this region was probably a complex of lowland forest and riparian woodlands and scrubs. Many of the records appeared to be located near the road-rail corridor connecting the towns but there were also records from residential properties and riparian corridors including Ararat Creek and upper Bunyip River. The species was recorded from residential properties in both Garfield and Bunyip, and individual live animals were directly observed recently by the authors in the rail corridor two kilometres east of Bunyip (TC pers. obs.), and on land adjacent to the Longwarry Sports Oval (RW pers. obs.).

Bass Coast

Although Norris *et al.* (1979) described Southern Brown Bandicoots as 'widespread and fairly common on the coast and plains' between Wonthaggi and Corner Inlet there are only a few records of the species in the Bass Coast region. The earliest record of the species was in 1973 when an individual was trapped near Wonthaggi (Atlas of Victorian Wildlife unpubl.). Before 1750 this region probably contained a limited amount of suitable vegetation. Instead, the West Gippsland region was dominated by heavier soils that mainly supported Grassy Woodlands, Swamp Scrub, Damp Heathy Woodlands and Herb-rich Woodlands (DSE 2006). Records were restricted largely to the narrow band of Sand-Heathland/Damp Heathland that existed near the coast between Wonthaggi and Cape Patterson, particularly in what is now the Wonthaggi Heathlands Conser-vation Reserve. Small numbers of individuals have been trapped at the Wonthaggi Heathlands in recent years, confirming that the species still occurs there (P Homan 2008). However, low trapping rates within the reserve suggest the population there may be small. Outside of this discrete area of heathland, records were sparse with few, widely spaced records. These records include a fresh bandicoot carcass positively identified as a Southern Brown found in coastal scrub between Tarwin Lower and Walkerville in 2005 (I. Gunn pers. comm.). A southern brown bandicoot was collected from this region in 1977, but it is possible that some anecdotal records may in fact be of Long-nosed bandicoots, a species known to occur at nearby Cape Liptrap and Walkerville (Braithwaite 1978; Menkhorst and Seebeck 1995b). Following reports of 'bandicoot' sightings around Venus Bay, targeted surveys were conducted during 2006 but these did not record any direct evidence of either Long-nosed or Southern Brown Bandicoots (Mae Adams pers. comm.).

Discussion

Southern Brown Bandicoots appear to persist at a number of locations throughout the South Central region of Victoria. While there is evidence that the range of the species may have contracted in recent decades, populations still appear to be scattered across a number of sites between Frankston and Wonthaggi. Throughout this region the historic distribution of the species was determined largely by the distribution of sandy soils that supported dense heathy vegetation, particularly Heathy Woodland and Sand Heathland EVCs. This type of vegetation formed on deep, nutrient poor, siliceous podsols characteristic of early Pleistocene aeolian dune systems. Such soils are common throughout the extensive sand sheets that run south-east from the Frankston-Carrum area of Port Phillip Bay to Tyabb and Tooradin on the Western Port coast (Rosengren 1984). The highest density of bandicoot records in the study area occur within this region, particularly at sites such as the Royal Botanic Gardens Cranbourne and Pines Flora and Fauna Reserve, where relatively large patches of the original dense heathy vegetation remain. The sand sheets continue to the east and support discrete patches of Sand Heathland and Heathy Woodland both on French Island and in the region between Lang-Lang and the Gurdies on the eastern side of Western Port Bay.

Elsewhere in the study area this vegetation was probably less common. In the southern parts of the Mornington Peninsula, areas of aeolian dunefield occur at Sandy Point and in a broad area between Rosebud and Picnic Point (SGAP 1991; Sault 2003; Fig. 3). Bandicoots were previously known from these areas but Heathy Woodlands or similar dense scrubby vegetation appear to have been relatively uncommon on the Mornington Peninsula (DSE 2006). Instead, the vegetation of the Peninsula was probably dominated by more open woodland communities such as Damp Sands Herb-rich Woodlands (DSE 2006) that may be less likely to support dense populations of bandicoots. The lack of extensive areas of suitable vegetation may account for the relatively small number of records from this region. Similarly, vegetation on the Bass Coast may also have been dominated by more open woodlands with dense heathy communities largely restricted to a relatively small area on Cape Patterson, and the Southern Brown Bandicoot may have never been widespread in the region. Throughout many of these regions the species may have occupied dense thickets of swampy riparian scrub that formed in drainage lines.

Heathy vegetation like that occupied by Southern Brown Bandicoots elsewhere in the state was probably also uncommon in the area north of Western Port Bay. Instead, the heavier soils of the former Koo-Wee-Rup swamp originally supported extensive tracts of inundated Swamp Scrub interspersed by Swampy Riparian Scrubs, Woodlands and Grass-lands or Grassy wetlands (DSE 2006; Yugovic and Mitchell 2006). On the northern edge of the swamp in the foothills, the original vegetation was probably a mosaic of Swampy Riparian Scrub, Wet Heath-land and Damp (Clay) Heathland (DSE 2006). However, despite the lack of Heathy Woodland vegetation, bandicoots have been recorded at many sites throughout this region. The majority of records in the area occur on the margins of the outer swamp or where sand ridges or riparian corridors occur within the swamp. Bandicoots were recorded within areas believed to have formerly supported grasslands, particularly the Tooradin Grassland described by Yugovic and Mitchell (2006). To our knowledge Southern Brown Bandicoots have rarely been recorded in grassland habitats elsewhere in south-eastern Australia.

Bandicoots were reported from a range of sites throughout the Koo-Wee-Rup area, including many now dominated by exotic pasture, gardens, Box-thorn hedges, Blackberry or Gorse thickets. Bandicoots also occurred around woodpiles, car bodies, sheds and other low structures that probably provided suitable refuge. Individuals were known to scavenge for anthropogenic food around houses, chicken coops, rabbit hutches or livestock feed bins, and at some properties were apparently quite tolerant of humans. Individuals were also recorded from a number of locations in a narrow band stretching from Nar Nar Goon to Drouin. Locations included residential areas, recreation and farming land and a number of records along the road-rail corridor between Garfield and Longwarry.

Linear corridors such as drains, roads and rail reserves appeared to be a feature of bandicoot locations throughout the region north of Western Port Bay. Many of the sites where Southern Brown Bandicoots were recorded were near railway lines or drainage lines that contained some dense groundcover. Road-killed bandicoots were also recovered or reported where drains or other corridors intersected with roads (D Nicholls pers. obs.). There were few sizable patches of indigenous vegetation remaining in this part of the study area and bandicoots appeared to be utilizing the cover available in narrow strips of dense vegetation within a predominantly agricultural matrix.

The existence of the Koo-Wee-Rup population, in the absence of substantial patches of remnant native vegetation, is unusual. A number of authors have previously identified the conversion of high proportions of indigenous vegetation to agricultural land as a likely cause of population decline in the species (Ashby *et al.* 1990; Bennett 1990; Friend 1990; Menkhorst and Seebeck 1995). Paull (1995) found that the distribution of the species in South Australia was closely related to the distribution of remnant native vegetation, most of which was secured in public reserves. Brown (2004) did not identify any 'impor-

tant' populations in Victoria or New South Wales that existed away from such reserves. Bennett (1990) found that Southern Brown Bandicoots in south-west Victoria were predominantly confined to larger forest patches. Rees and Paull (2000) also concluded that the species made only limited use of linear reserves in agricultural landscapes in the Portland region. They found no evidence that the species either persisted in such locations or used them to disperse between neighbouring patches of remnant vegetation. The rarity of bandicoots at such sites has been attributed in part to high predation pressure, particularly from introduced foxes (Rees and Paull 2000). However, a number of other key threatening processes may also disproportionately affect populations in linear reserves. These include road mortality, weed invasion, inappropriate fire regimes and stochastic effects related to small effective population size. How bandicoots manage to persist under such conditions remains somewhat mysterious. Unfortunately reports from some local residents suggest that these populations may have declined in recent decades.

There is also indication of a decline in known Southern Brown Bandicoot populations in several dedicated conservation reserves in the south central region within the past two decades. Brereton *et al.* (2004) noted that a 'good' population of Southern Brown Bandicoots occurred at Langwarrin Flora and Fauna Reserve (and adjacent land) in the late 1980s. The species was also thought to be relatively common on publicly reserved land near Tyabb (Yaringa) during the 1970s (Braithwaite *et al.* 1980). The species has not been definitively recorded at either site since 1990 despite some targeted efforts in recent years (Leon Costermans pers. comm.; Fauna Survey Group Victoria unpublished data; Darren Quinn pers. comm.; TC unpublished data.; Darren Southwell pers. comm.). The population at The Pines was also once thought to be relatively dense (Taylor 1999; Hans Brunner pers. comm.) with multiple individuals readily captured or otherwise detected during the 1980s and 90s. Although the species was recently confirmed as still present at The Pines, there was clear indication that it no longer occurred at sites within the reserve where it had been recorded during earlier surveys (Norris and Associates 1993, Kimber 1997; Hans Brunner pers. comm.; TC and DN unpublished data). The population remaining in the reserve may now be critically small and its isolation from other populations in the region makes it highly vulnerable to extinction. Elsewhere on the Mornington Peninsula the species has not been definitively recorded in conservation reserves since at least 1987.

Conclusions

The results of the current study give rise to concern about the remaining populations of Southern Brown Bandicoots in the south central region of Victoria. The region generally supports only small, isolated populations, many of which face potentially high levels of threat. We could identify only one moderately dense, stable population of Southern Brown Bandicoots in a secure nature reserve in the entire region. Populations in most other reserves now appear to be very small andsome have disappeared in recent decades. The size of two known extant populations at The Pines Flora and Fauna Reserve and Wonthaggi Heathlands Reserve are unclear but the low level of reporting and low trap and sign detection success gives rise to concern they may contain only a small number of individuals. While both populations may be small, 'The Pines' population appears to be particularly vulnerable and may have declined substantially in recent decades. The area ariound The Pines has urbanized rapidly in the last 10 years and the population in the reserve probably faces increasing threats from a range of factors linked to urbanization. Many of the threats facing the population appear difficult to manage because of the proximity of residences and the restrictions this places on appropriate management actions. Unfortunately, the history of similar populations elsewhere in the region suggests that without effective management the population will almost inevitably become extinct.

While Southern Brown Bandicoots appear to have a restricted distribution throughout much of South Central Victoria, they were surprisingly wide-

spread in the Koo-Wee-Rup region. Although not exhaustive, our records suggest four main clusters of records occur mainly on unsecured land near Koo-Wee-Rup, Bayles, Cardinia and Garfield-Longwarry. Publicly reserved habitat is rare in this region, and the species appears to survive in a highly modified agricultural landscape where it exploits a range of anthropogenic resources. Unfortunately, however, the populations in this area are vulnerable because most of the habitat occupied by bandicoots is on private or utility land and subject to high levels of a number of threatening processes. Experience elsewhere in the region does not give great confidence that this type of habitat is capable of sustaining bandicoot populations in the medium to long term unless coordinated actions are implemented throughout the region to manage the threats. Indeed, there is some anecdotal evidence that at least some of these populations have declined in recent decades. There is now a clear need to determine the size and extent of these populations and to develop management responses that operate effectively across multiple land tenures.

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Ecological attributes of strategic land acquisitions for addition to Victoria's public protected area estate (2006-2007)

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Abstract
The development of a comprehensive, adequate and representative reserve system is the key objective of the National Reserve System, and is supported by all Australian States and Territories. In Victoria, the purchase of private land for incorporation into the parks and reserves system assists in the protection of some of the State's most endangered ecosystems. This article outlines the ecological attributes of private land purchased for addition to the Victorian public protected area system in 2006 and 2007. (*The Victorian Naturalist* **125** (5), 2008, 140-149)

Introduction

This article documents some of the more significant land purchases made by the Department of Sustainability and Environment (DSE) for addition to the public conservation estate from early 2006 until late 2007, and provides a brief description of their ecological attributes. It serves as an extension to previous descriptions of the operation of the Department's Conservation Land Purchase Program in Victoria (see Fitzsimons and Ashe 2003, Fitzsimons *et al.* 2004, 2006). The program aims to systematically improve the comprehensiveness, adequacy, and representativeness (CAR) of the reserve system, with particular emphasis on high-quality examples of threatened and under-reserved ecosystems such as native grasslands and grassy woodlands. All acquisitions are on a completely voluntary basis. The program complements the work of the Victorian Environmental Assessment Council (VEAC) (and its predecessors) on public land, and the Trust for Nature and other programs (e.g. BushTender, Land for Wildlife) seeking to protect biodiversity on private land.

Purchase priorities are derived from published and internal inventories of the most significant sites containing threatened ecosystems throughout Victoria and are assessed in relation to the comprehensiveness, adequacy and representativeness of the existing reserve system. The Department also purchases private land to link park and reserve areas and remove inliers in order to consolidate protected habitat and alleviate potential management problems. All purchases described in this paper are managed for the conservation of biodiversity by Parks Victoria – except Branxholme Nature Conservation Reserve, which will be managed by a committee of management.

The conservation status of all species listed in this paper are outlined in Appendix 1, while Appendix 2 lists communities listed under the *Flora and Fauna Guarantee Act 1988* (FFG) protected by the new reserves. Fig. 1 indicates the location of recent purchases within Victoria.

1. Branxholme Swamp Scrub

This small property at Branxholme in the Victorian Volcanic Plain bioregion contains endangered Woolly Tea-tree *Leptospermum lanigerum*-dominated Swamp Scrub Ecological Vegetation Class (EVC). There is a strong presence of the FFG-listed Curly Sedge *Carex tasmanica*. The site is associated with Arrandoovong Creek where native fish species such as Shortfin Eel *Anguilla australis*, River Blackfish *Gadopsis marmoratus*, Common Galaxias *Galaxias maculatus*, Mountain Galaxias *G. olidus* and Southern Pigmy Perch

Fig. 1. Location of recent land purchases (numbered) for addition to the reserve system (existing reserve system shaded).

Nannoperca australis have been recorded directly adjacent to the purchased land.

It has been added to the adjoining public land to form the new three hectare Branxholme Nature Conservation Reserve.

2. Ecklin South Swamp

The purchase of the 35 ha Ecklin South Swamp, near Timboon, protects a range of vegetation classes in the Victorian Volcanic Plain bioregion, a national biodiversity hotspot. Deep Freshwater Marshes are considered endangered in the bioregion, having been reduced to less than 30% of their original extent and facing ongoing threats to their viability. Fringing vegetation communities, including Swamp Scrub, Damp Heath Scrub and Scoria Cone Woodland EVCs, also are considered endangered or vulnerable in the bioregion.

Ecklin South Swamp has formed in a peat-filled crater that is partly drained (Fig. 2) (see Gill (1947) for a description of the formation of Ecklin Swamp and Ecklin Hill to the north). The swamp provides a breeding area for a number of species of waterbirds. It is the largest remaining permanent wetland in the region and it provides a refuge for waterfowl during prolonged periods of drought. Ecklin South Swamp is a nationally significant wetland listed under the *Directory of Important Wetlands in Australia* (Environment Australia 2001), as part of the Cobden-Terang Volcanic Craters (it is known as 'Bailey's Swamp' or 'Ecklin Swamp' in various versions of the Directory).

The Woolly Tea-tree-dominated Swamp Scrub provides likely habitat for the nationally-vulnerable Swamp Greenhood *Pterostylis tenuissima* and Small Sickle Greenhood *Pterostylis* sp. aff. *furcata* (endangered in Victoria).

The swamp protects important and permanent habitat of the nationally-vulnerable Growling Grass Frog *Litoria reniformis*, and the populations present at this site may be important for recolonisation of adjacent sites following population declines or extinctions. A number of vulnerable waterbird species, including Australasian Shoveller *Anas rhynchotis*, Royal Spoonbill *Platalea regia*, Hardhead *Aythya australis* and Musk Duck *Biziura lobata* have been recorded using the swamp.

The new reserve is known as the Ecklin South Swamp Nature Conservation Reserve.

Fig. 2. Aerial photograph (2003) of Ecklin South Swamp. The dashed white line represents the reserve boundary. Source: DSE.

3. Warrak Herb-rich Woodlands, Langi Ghiran

This 42 ha addition to the north-east boundary of Langi Ghiran State Park contains mostly Hills Herb-rich Woodland, a vulnerable EVC in the Central Victorian Uplands bioregion. A small amount of endangered Damp Sands Herb-rich Woodland is also present, while the depleted Grassy Dry Forest makes up the remainder.

4. Korrak Korrak Grasslands

This 130 ha high quality Chenopod Grassland and Riverine Chenopod Woodland at Korrak Korrak was purchased in 2006 to form the new Korrak Korrak Nature Conservation Reserve (Figs. 3 and 4). Chenopod Grassland, which is endangered in the Victorian Riverina bioregion, occupies approximately 107 ha of the property, while the vulnerable Riverine Chenopod Woodland occurs on the remaining 23 ha.

The highly diverse site contains a number of significant flora species, including only the second Victorian record of the bindweed *Convolvulus graminetinus*, populations of the nationally vulnerable Chariot Wheels

Fig. 3. Mix of species in the Korrak Korrak grasslands, including Golden Sunray *Hyalosperma glutinosum* subsp. *glutinosum*, Hairy Bluebush *Maireana pentagona*, Paper Sunray *Rhodanthe corymbiflora*, Short-wing Saltbush *Sclerochlamys brachyptera* and Stiff Cup-flower *Pogonolepis muelleriana*. Photo: James Fitzsimons.

Maireana cheelii, as well as Leafless Bluebush *M. aphylla*, Rohrlach's Bluebush *M. rohrlachii*, Cane Grass *Eragrostis australasica*, and Smooth Minuria *Minuria integerrima*. Pale Spike-sedge *Eleocharis pallens* is known from adjoining grasslands. The site has been considered a high priority for purchase by DSE for a number of years. Its purchase complements other purchases of native grassland for conservation at Korrak Korrak and nearby Budgerum by the Trust for Nature (O'Brien 2004; Trust for Nature 2007).

In 2008 the Victorian Environmental Assessment Council recommended the adjoining public land along Back Creek be added to Korrak Korrak Nature Conservation Reserve to form a larger reserve of some 273 ha (VEAC 2008). This Black Box *Eucalyptus largiflorens* and Tangled Lignum *Muehlenbeckia florulenta* creekline links to the Trust for Nature owned Korrak Korrak Grasslands Reserve and eventually to Yassom Swamp to the north (the latter recommended by VEAC (2008) to be incorporated into a new Leaghur-Koorangie National Park).

5. Roslynmead East Grasslands, Patho Plains

The addition of 122 ha of endangered Northern Plains Grassland and Lignum Wetland to the reserve system complements other recent purchases by DSE and the Trust for Nature on the Patho Plains that have sought to increase the protection of grasslands in one of the largest areas remaining in Victoria (see Fitzsimons and Ashe 2003, Fitzsimons *et al.* 2004, 2006). The site is of very high significance due to the lack of cultivation and long-term light grazing regime. There has been virtually no mechanical disturbance over 80% of the property, with a small section cropped approximately 30 or more years ago.

The grassland is likely to provide habitat for Plains-wanderer *Pedionomus torquatus*, with a population recently recorded from the nearby Kotta Nature Conservation Reserve. Baker-Gabb (2001) indi-

Fig. 4. Grassland and Black Box woodland on Korrak Korrak Nature Conservation Reserve. Photo: Deanna Marshall.

cated that all suitable native grasslands within a 40 km radius of Terrick Terrick National Park play a key role in conserving this nationally vulnerable species. The grassland also provides habitat for a number of other significant fauna species recorded in nearby native grasslands, such as Curl Snake *Suta suta* and Fat-tailed Dunnart *Sminthopsis crassicaudata*.

The scattered Umbrella Wattle *Acacia oswaldii* have all died over the past 30 years – possibly due to the effects of grazing on recruitment. Significant flora species that have been recorded on the site include Red Swainson-pea *Swainsona plagiotropis*, Silky Swainson-pea *S. sericea*, Frosted Goosefoot *Chenopodium desertorum* subsp. *virosum* and Leafless Bluebush, while a number of other species occurring on nearby native grasslands are likely to occur here (e.g. Slender Darling-pea *S. murrayana*, Downy Swainson-pea *S. swainsonioides* and Woolly Mantle *Eriochlamys behrii*).

The new reserve is known as the Roslynmead East Nature Conservation Reserve and has recently been recommended for inclusion in an expanded Terrick Terrick National Park (VEAC 2008).

6. Neilborough Whipstick

This 130 ha property at Blandfords Road, Neilborough, is an inlier within the Greater Bendigo National Park and has been purchased for addition to this park. It comprises areas of remnant Sandstone Ridge Shrubland and Box-Ironbark Forest with large old Red Ironbark *Eucalyptus tricarpa*, as well as stands of the rare Kamarooka Mallee *E. froggattii* and a variety of orchid species. An area that appears to have been historically cleared is recovering well with a high cover of Wallaby Grass *Austrodanthonia* sp. and scattered Drooping Cassinia *Cassinia arcuata* and Whirrakee Wattle *Acacia williamsonii*. There are two drainage lines through the mallee with medium sized Yellow Gums *Eucalyptus leucoxylon*, a vegetation type that provides potentially suitable habitat for the nationally endangered Whipstick Westringia *Westringia crassifolia*.

This addition complements 163 ha of land, which as a result of vegetation off-

sets, has recently been added to the Whipstick and Kamarooka sections of the Greater Bendigo National Park.

7. Welsh Village, Chewton

This 9.2 ha property near Chewton was purchased for its historic and cultural values, namely as part of the former Welsh Village, and includes a late 19th century quartz gold mine. The site contains Heathy Dry Forest with large trees and an understorey in good condition. The site will be added to the adjoining Castlemaine Diggings National Heritage Park.

8. Holylands Swamp, Caniambo South

This 129 ha property at Caniambo South, south-east of Shepparton, contains remnants of two endangered EVCs, and includes the bioregionally significant Holylands Swamp (Fig. 5). The remnant vegetation on the property represents one of the largest patches of native vegetation left in the Sheep Pen Creek district. Occurring on the riverine plain, it has a natural drainage line that flows through the property and links Holylands Swamp with other wetlands in the district. There are relatively few wetlands in the Victorian Riverina bioregion reserved in strict nature conservation reserves (Robertson and Fitzsimons 2005).

The Red Gum Swamp EVC is dominated by River Red Gum *Eucalyptus camaldulensis* of all age classes, but with large numbers of mature trees. The wetland habitat ranges from open wetlands to tree-dominated swamps. The groundcover is dominated by Brown-back Wallaby-grass *Austrodanthonia duttoniana*, Swamp Wallaby-grass *Amphibromus* sp., rushes *Juncus* sp. and Common Spike-sedge *Eleocharis acuta*. The Plains Grassy Woodland EVC is mostly cleared, apart from scattered, mature Grey Box *Eucalyptus microcarpa*.

Considering the size of the site, restoration of the mostly cleared Plains Grassy Woodland EVC should assist with the conservation of the Grey-crowned Babbler *Pomatostomus temporalis*, an endangered species whose stronghold in north-east Victoria is the Sheep Pen Creek district (Robinson 2006).

The new reserve is known as the Caniambo South Nature Conservation Reserve.

9. Rainbow Gully, Olinda

This 21 ha property represents a relatively large inlier within the Dandenong Ranges National Park. The land has over 60% cover of native Shrubby Foothill Forest, Wet Forest and Damp Forest, including Mountain Ash *Eucalyptus regnans*, Mountain Grey Gum *E. cypellocarpa*, Narrow-leaf Peppermint *E. radiata*, Messmate Stringybark *E. obliqua* and deep fern gullies. The purchase of this block for addition to the Dandenong Ranges National Park consolidates the park and removes a number of potential threats.

10. 'Grassy Swamp', French Island

The addition of the 27 ha 'Grassy Swamp' to the French Island National Park adds a grassy wetland community not previously represented in the park. The intact

Fig. 5. Holylands Swamp, Caniambo South Nature Conservation Reserve. Photo: Lance Williams.

ephemeral swamp includes large mosaics of sedges, rushes and other aquatic vegetation, including native grasses such as *Agrostis*, *Deyeuxia*, *Danthonia* and *Microlaena*, which dominate large areas of the block. Areas of Swamp Scrub (an endangered EVC) and Wet Heathland occur around the swamp margin. The swamp fills from drainage lines within the park connected to the Heifer, Little Heifer and Prairie Swamps system.

The swamp provides seasonal open water and important habitat for migratory waders and the critically endangered Orange-bellied Parrot *Neophema chrysogaster*, as well as other significant species such as Blue-winged Parrot *N. chrysostoma* and King Quail *Excalfactoria chinensis victoriae*. French Island is considered the most important area in Victoria for the latter endangered species (O'Brien 2006).

11. Ben Winch Swamp, Holey Plains

This 178 ha property contains Ben Winch Swamp and surrounding ecosystems and was purchased for addition to the Holey Plains State Park, south of Rosedale (Fig. 6). Located in the Gippsland Plain bioregion, it contains threatened wetland ecosystems (deep freshwater marsh/sedge wetland), and vulnerable Lowland Forest, Riparian Scrub and Damp Sands Herb-rich Woodland EVCs. Ben Winch Swamp has been identified as a site of regional zoological and geological/geomorphological significance (Rosengren *et al.* 1981). The adjacent Holey Plains State Park has been classified as a site of national zoological and botanical significance (Mansergh and Norris 1982; Gullan *et al.* 1984).

This complex wetland is over 1500 metres long and lies in a broad valley eroded in Tertiary sediments. Unlike any other swamps or lakes in the Stradbroke-Holey Plains area, Ben Winch Swamp has prominent relict spits that extend from the southern shoreline and divide the basin into five segments (Rosengren *et al.* 1981). The vegetation is of very high quality and, despite disturbance to part of the wetland prior to 1998 (in the form of peat extraction), the area is rehabilitating well.

The property supports some of the westernmost examples of Coast Grey Box *Eucalyptus bosistoana* forests in good condition, a community which is much reduced from its former range and with many remaining stands in poor condition.

The site also supports the nationally endangered Dwarf Kerrawang *Rulingia prostrata*. Although now understood to be more widespread than previously thought, many of the sites are on private property and prone to degradation through grazing and weed encroachment (N. Walsh pers. comm. 2007). The importance of Ben Winch Swamp for this species is highlighted in the FFG Action Statement (James 2003). Other significant flora species recorded on the site include the nationally-vulnerable Wellington Mint-bush *Prostanthera galbraithiae* and a significant westerly range extension for the Slender Mat-rush *Lomandra confertifolia* subsp. *leptostachya* (N. Walsh pers. comm. 2007).

Surveys in the area have confirmed that the Lowland Forest and Heathy Woodland on the property are part of the territory of one or more Powerful Owls *Ninox strenua*. In addition, a recent record several kilometres to the west suggests that it is possible that the area is also used by the endangered Masked Owl *Tyto novaehollandiae*, which inhabits more open forests and woodlands and occurs on the forest-cleared land interface, both of which are present at Ben Winch Swamp (R Willig pers. comm. 2007).

12. Bengworden Grassy Woodlands

This 106 ha property at Bengworden, west of Bairnsdale, contains a number of endangered grassy ecosystems of very high conservation significance. The vegetation is dominated by Plains Grassy Woodland (specifically, the FFG-listed Forest Red Gum Grassy Woodland; see front page), with smaller areas of the endangered Plains Grassy Wetland and vulnerable Damp Sands Herb-rich Woodland. Its purchase improves the conservation of these threatened EVCs within the Gippsland Plains bioregion. The vegetation is of high quality with limited areas of disturbance, consistent with a history of grazing with no attempt to establish introduced pasture. The site is considered one of the highest quality examples of known remnants of Plains Grassy Woodland on the Gippsland Plains, after Mooramung Flora and Fauna

Fig 6. Ben Winch Swamp and fringing vegetation. Photo: Melissa Ainsworth.

Reserve to the north (R Edwards pers. comm. 2007).

The rare Bear's-ear *Cymbonotus lawsonianus* has been recorded on the property. No fauna surveys have been undertaken to date.

This purchase enhances landscape connectivity and habitat linkages with areas of Plains Grassy Woodland covenanted with Trust for Nature on adjoining and nearby properties, and contributes to the Gippsland Plains Conservation Management Network (Fitzsimons and Wescott 2005).

The new reserve is known as the Bengworden Nature Conservation Reserve.

Other purchases

Two properties containing Wet Forest and Damp Forest EVCs totalling 30 ha at Kinglake and St Andrews North have been added to the Kinglake National Park to rationalise park boundaries. A small area (0.8 ha) of Chenopod Shrubland was added to the existing Winlaton Nature Conservation Reserve purchased in 2004 (see Fitzsimons *et al.* 2006)

Future directions for land purchase and the protected area system

Such strategic acquisitions, combined with other instruments to protect ecosystems on private land, ultimately aim to improve the completeness, adequacy and representativeness of Victoria's protected area system. The funding and negotiation for purchase of other poorly represented ecosystems is currently in progress. Particular emphasis is on native grasslands and grassy woodlands. The Department's efforts are complemented by those of the Trust for Nature (Victoria) which has purchased and continues to purchase properties containing grassy and other threatened ecosystems throughout the State as part of the National Reserve System Program. Increasingly, creative solutions are being sought between DSE and the Trust to secure important conservation lands (see Fitzsimons and Davies 2005).

Acknowledgements

Thanks to the following people who originally provided descriptions of the sites listed in this paper and/or assisted in their purchase, in particular: Melissa Ainsworth, Mick Douglas, Robyn Edwards, Andy Govanstone, Greg Leece, Deanna Marshall, Steve McDougall, Rob Price, Doug Robinson, Susan Taylor, Neville Walsh, Alan Webster, Rolf Willig and Nathan Wong. Thanks to all other individuals and organizations that have contributed to the land purchase process in general. The sympathetic management practices employed by previous owners of

these properties have ensured the maintenance of these remnants. Many of the past owners still have a strong connection to the new protected areas. The Commonwealth Government, through the National Reserve System Program of the Natural Heritage Trust, provided funding for the purchase of a number of these properties.

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Appendices

Appendix 1. Some species occurring (or likely to occur) on recently purchased land (and their conservation status). Abbreviations: (Victorian Status) ce, critically endangered; e, endangered; v, vulnerable; r, rare; n, near threatened; k, poorly known/data deficient; (FFG) L, listed under the *Flora and Fauna Guarantee Act 1988*; (Commonwealth Status) CE, critically endangered; E, endangered; V, vulnerable. Derived from DSE (2005, 2007), *Flora and Fauna Guarantee Act 1988* and *Environment Protection and Biodiversity Conservation Act 1999*. Note: This table does not represent all species occurring in the above-mentioned reserves.

	Scientific Name	Common Name	Vic Status	FFG	Cwlth Status
Mammals	*Sminthopsis crassicaudata*	Fat-tailed Dunnart	k		
Birds	*Anas rhynchotis*	Australasian Shoveller	v		
	Aythya australis	Hardhead	v		
	Biziura lobata	Musk Duck	v		
	Excalfactoria chinensis victoriae	King Quail	e	L	
	Neophema chrysogaster	Orange-bellied Parrot	ce	L	CE
	Neophema chrysostoma	Blue-winged Parrot			
	Ninox strenua	Powerful Owl			
	Pedionomus torquatus	Plains-wanderer	ce	L	V
	Platalea regia	Royal Spoonbill	v		
	Pomatostomus temporalis	Grey-crowned Babbler	e	L	

Appendix 1. cont'd.

	Scientific Name	Common Name	Vic Status	FFG	Cwlth Status
	Tyto novaehollandiae	Masked Owl	e	L	
Reptiles	*Suta suta*	Curl Snake			
Amphibians	*Litoria raniformis*	Growling Grass Frog	e	L	V
Fishes	*Anguilla australis*	Shortfin Eel			
	Galaxias maculatus	Common Galaxias			
	Galaxias olidus	Mountain Galaxias		L	
	Gadopsis marmoratus	River Blackfish			
	Nannoperca australis	Southern Pigmy Perch			
Plants	*Acacia oswaldii*	Umbrella Wattle	v		
	Acacia williamsonii	Whirrakee Wattle	r		
	Austrodanthonia duttoniana	Brown-back Wallaby-grass			
	Carex tasmanica	Curly Sedge	v	L	V
	Cassinia arcuata	Drooping Cassinia			
	Chenopodium desertorum subsp. *virosum*	Frosted Goosefoot	k		
	Convolvulus graminetinus	Bindweed			
	Cymbonotus lawsonianus	Bear's-ear	r		
	Eleocharis acuta	Common Spike-sedge			
	Eleocharis pallens	Pale Spike-sedge	k		
	Eragrostis australasica	Cane Grass	v		
	Eriochlamys behrii	Woolly Mantle	r		
	Eucalyptus bosistoana	Coast Grey Box	r		
	Eucalyptus camaldulensis	River Red Gum			
	Eucalyptus froggattii	Kamarooka Mallee	r	L	
	Eucalyptus largiflorens	Black Box			
	Eucalyptus leucoxylon	Yellow Gum			
	Eucalyptus microcarpa	Grey Box			
	Eucalyptus tricarpa	Red Ironbark			
	Hyalosperma glutinosum subsp. *glutinosum*	Golden Sunray			
	Leptospermum lanigerum	Woolly Tea-tree			
	Lomandra confertifolia subsp. *leptostachya*	Slender Mat-rush			
	Maireana aphylla	Leafless Bluebush	k		
	Maireana cheelii	Chariot Wheels	v	N	V
	Maireana pentagona	Hairy Bluebush			
	Maireana rohrlachii	Rohrlach's Bluebush	k		
	Minuria integerrima,	Smooth Minuria	r		
	Muehlenbeckia florulenta	Tangled Lignum			
	Pogonolepis muelleriana	Stiff Cup-flower			
	Prostanthera galbraithiae	Wellington Mint-bush	v	N	L
	Pterostylis sp. aff. *furcata*	Small Sickle Greenhood	e		
	Pterostylis tennissima	Swamp Greenhood	v		V
	Rhodanthe corymbiflora	Paper Sunray			
	Rulingia prostrata	Dwarf Kerrawang	e	L	E
	Sclerochlamys brachyptera	Short-wing Saltbush			
	Swainsona murrayana	Slender Darling-pea	e	L	V
	Swainsona plagiotropis	Red Swainson-pea	e	L	V
	Swainsona sericea	Silky Swainson-pea	v		
	Swainsona swainsonioides	Downy Swainson-pea	e	L	
	Westringia crassifolia	Whipstick Westringia	e	L	E

Appendix 2. Some listed *Flora and Fauna Guarantee Act 1988* communities occurring on recently purchased land.

Northern Plains Grassland	Victorian temperate-woodland bird community
Forest Red Gum Grassy Woodland	

Host selection and relative abundance of the Finger Fern *Grammitis billardieri* with regard to vegetation type at Mt Erica, Victoria

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Abstract
Despite the important role of vascular epiphytes in temperate rainforests, there are gaps in the literature regarding the factors driving their distribution patterns, including host tree specificity. This brief study attempts to determine the host preferences and relative abundance of the Finger Fern *Grammitis billardieri* (Willd.) in Cool Temperate Rainforest and Wet Sclerophyll Forest at Mt. Erica, Victoria. Both the type of host used and the relative abundance of the Finger Fern were significantly associated with vegetation type. The distribution of this species appears to be related to host characteristics, and therefore the conservation of this species will largely depend on the management of host tree populations, especially within the threatened temperate rainforest ecosystems. (*The Victorian Naturalist,* **125**, (5), 2008, 150-153)

There is little published knowledge regarding factors that affect the distribution and abundance of ferns, particularly smaller ferns, in temperate vegetation types . The Finger Fern *Grammitis billardieri* Willd. is a small (fronds <150 x 12 mm), epiphytic fern that occurs in moist, shady areas of southern Australia and New Zealand at altitudes between 100 and 1150 m. The Finger Fern commonly occurs on a range of living and dead tree species, but can also be lithophytic i.e. occur on rocks. The widespread decline of rainforest throughout Australia since late Cenozoic times has substantially impacted the distribution of this species, which is most abundant in these ecosystems. This study investigated (1) the range of host species used by *G. billardieri*, and (2) whether host selection and relative abundance of *G. billardieri* varied between Cool Temperate Rainforest (CTR) and Wet Sclerophyll Forest (WSF).

Data was collected from pockets of CTR and WSF at Mt Erica in Baw Baw National Park. Three north-south transects were sampled in each of the vegetation types, with each transect separated by at least 10 m. Each transect was sampled for 40 minutes, with the host type and abundance of the Finger Fern (n=<10, 10-50, >50) recorded wherever it occurred along each transect. The boundary between CTR and WSF was determined by the presence of Mountain Ash *Eucalyptus regnans* F. Muell., which signified a transition into WSF. A transition zone of 20 m between the two vegetation types was not sampled.

Grammitis billardieri were recorded at 115 points along the transects, 46 times in WSF, and 69 times in CTR (Fig. 1). Six different hosts were used by the plant, both organic hosts (live and dead trees) and non-organic hosts (boulders). Both Mountain Ash and Mountain Correa *Correa lawrenceana* Hook. occurred only in the WSF, and so were excluded from the statistical analyses.

The hosts used by *G. billardieri* in this study were similar to those found in published literature. Gullan and Walsh (1986) stated that the Finger Fern was found on 'rocks, logs, or trunks of trees and tree-ferns'. Kellar *et al.* (2006) found the fern on both Myrtle Beech *Nothofagus cunninghamii* (Hook.) Oerst., and Mountain Ash. Wakefield (1975) reported the fern occurring on rocks, logs and tree-ferns, but noted that they occurred more often on the mossy trunks of Myrtle Beech, Kanooka *Tristaniopsis laurina* Sm. and Sassafras *Atherospermum moschatum* Labill. The lack of fern presence on Kanooka in this study was due to a lack of this species in the study area. Sassafras did occur in the area, but not along the transects investigated.

That no *G. billardieri* was recorded growing on tree-ferns was surprising, considering their known suitability as Finger Fern hosts. However, not only were there few tree-ferns along the transects, but those that were pre-

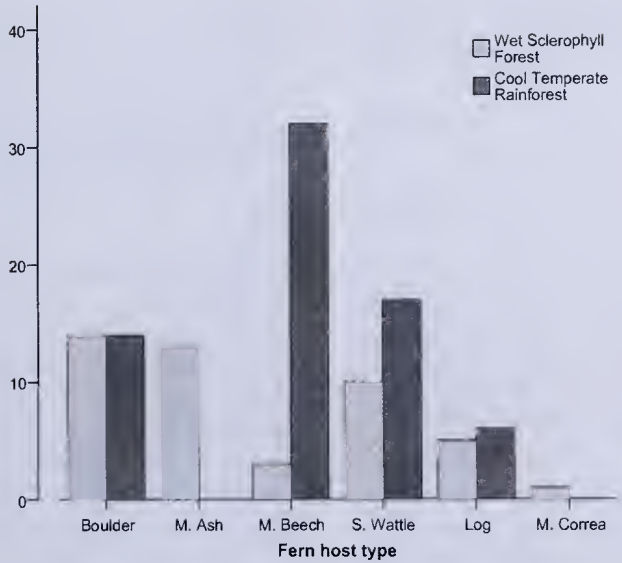

Fig. 1. The occurrence of *Grammitis billardieri* on different hosts in Wet Sclerophyll Forest (n=46) and Cool Temperate Rainforest (n=59) at Mt Erica. (Sampling effort = 40 minutes in each vegetation type).

sent were predominantly short (< 2 m). Short tree-ferns are known to have fewer epiphytes than taller ones, due to the skirt formed by old fronds preventing light and rain from entering the upper region of the trunk (Page and Brownsey 1986; Ford and Gibson 2000; Floyed and Gibson 2006).

There was a significant association between the vegetation type and the host species used by the Finger Fern (χ^2 =14.299, df =3, p =0.003). The occurrence of the fern in rainforest was equal to or greater than the occurrence in forest for all of the host types (Fig. 1). The very distinct difference in Myrtle Beech use as a host between vegetation types suggests that this host-use difference has biological significance.

These results suggest that the suitability of some hosts for the Finger Fern may change with respect to the vegetation type the host is located in. Logs and boulders, which occurred in similar proportions in both WSF and CTR, had almost exactly the same occurrence of the target species. None of the published literature on *G. billardieri* (Parris 1975; Wakefield 1975; Parris 1983; Gullan and Walsh 1986) indicates a preference for rocks or logs, in either vegetation type, and therefore they are believed to offer similar opportunities for colonisation by the fern. This suggests that the differences recorded in Myrtle Beech and Silver Wattle use are probably driven more by variation in the host tree characteristics than by broad environmental variables among the vegetation types. This is similar to results from other studies (e.g. Callaway *et al.* 2002; Munoz *et al.* 2003; Mehltreter *et al.* 2005; Laube and Zotz 2006a; 2006b), which show colonisation by vascular epiphytes correlated to specific host tree attributes, including tree size and bark characteristics.

There was a higher occurrence of *A. dealbata* as a host in the CTR, although it was relatively common in both vegetation types within the study area. While *N. cunninghamii* occurred in higher numbers in the CTR, it had a substantial presence in the WSF, especially in the areas close to the rainforest. The use of *N. cunninghamii* as a host was more than an order of magnitude greater in the CTR, which strongly suggests that factors other than chance are

responsible for its increased utilisation as a host. This apparent 'preference' for *N. cunninghamii* as a host in CTR is supported by Wakefield (1975), who noted a higher occurrence of *G. billardieri* on the trunk bases of some trees, including Myrtle Beech, than on logs, rocks or tree-ferns in rainforest ecosystems.

The difference in host use between CTR and WSF is probably due to an interaction of host factors (e.g. bark properties and tree size), with a lesser effect from environmental variables, including moisture levels and light-related factors (Callaway *et al.* 2002; Munoz *et al.* 2003; Mehltreter *et al.* 2005; Laube and Zotz 2006a). Callaway *et al.* (2002) found that water-holding capacity of the host's bark highly correlated with the presence of epiphytic ferns. However, they also found that while some ferns are particularly associated with specific host species, host traits favouring colonisation did not fully explain this relationship. It may well be that *N. cunninghamii*, for example, has bark properties (i.e. water-holding capacity) favouring establishment of the Finger Fern in CTR; however, the decrease in moisture in WSF results in other physical properties exerting greater influence on colonisation.

Because our study measured only the relative abundance of ferns, and not that of the host species, quantitative analysis of the changing proportions of host colonisation is imprecise. Knowing exact ratios of colonisation for the different hosts would assist in detecting further changes in host suitability between CTR and WSF.

There was a significant association between the vegetation type and the abundance of the Finger Fern (χ^2 =21.763, df =2, p <0.001). The WSF had a slightly greater occurrence of *G. billardieri* at low abundance, substantially less at a medium abundance, and no occurrence at high abundance (Fig. 2).

Our results showed that the relative abundance of *G. billardieri* differed significantly between the WSF and the CTR, with substantially greater occurrence in the 10-50 and >50 abundances in the CTR. This highly significant difference (p<0.001) indicates that factors other than chance are driving the relative abundance of the Finger Fern at Mt Erica.

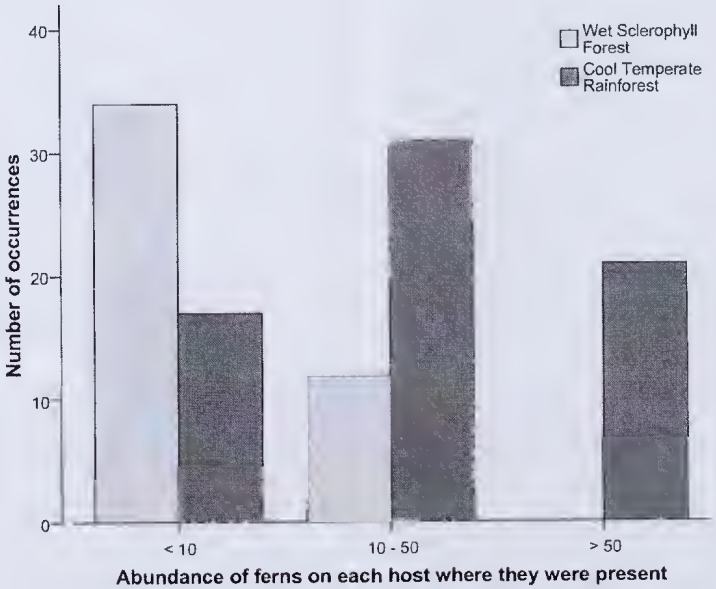

Fig. 2. The occurrence of *Grammitis billardieri* at different abundances in Wet Sclerophyll Forest (n=46) and Cool Temperate Rainforest (n=69) at Mt Erica.

Factors likely to be responsible for the increase in relative abundance in CTR include: increased levels of moisture and humidity (Callaway *et al.* 2002; Lobel *et al.* 2006), more favourable conditions of the substrate, such as higher water-holding capacity (Mehltreter *et al.* 2005), and vegetation-driven variables such as light attenuation through the canopy (Callaway *et al.* 2002).

While this study did not incorporate host size parameters, tree size is likely to have an effect on the abundance of epiphytic ferns, due to increased surface area, accumulation of epiphytes through time, and changes in bark characteristics (Zimmer-man and Olmsted 1992; Munoz *et al.* 2003). Laube and Zotz (2006a) suggested that population dynamics of vascular epiphytes, especially dispersal-related factors, were responsible for the greater recruitment on larger hosts. Similarly, Lobel *et al.* (2006) found that the age of host trees (generally linearly associated with size) affected the dispersal and metapopulation dynamics of epiphytic ferns, with a general increase in species richness with increased age.

Conclusion

The presence of the Finger Fern on hosts in CTR and WSF was not a random occurrence; however, specific host selection between these vegetation types was not determined. Host tree selection by *G. billardieri* in CTR and WSF may well be a reflection of the changing environmental gradients that drive the distinction between these vegetation types.

When considered together, the differential use of hosts between vegetation types, and the substantial increase in relative abundance in CTR, indicate that the Finger Fern requires specific vegetation and environmental conditions to thrive. These conditions are the most favourable in areas of undisturbed Cool Temperate Rainforest, and therefore planning for the conservation of this species should centre on further protection of these rainforests in southern Australia.

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Dear Editor,

I wish to take this opportunity to sincerely apologise to Mr Ian Faithfull of Victoria University and the Victorian Department of Primary Industries, for failing to acknowledge him in the paper 'Golden Sun Moth *Synemon plana* (Lepidoptera: Castniidae): results of a broad survey of populations around Melbourne' (*The Victoria Naturalist* **125**: 39-46).

Ian was responsible for finding one of the populations mentioned in the paper (site 15), which in turn led the authors to investigate sites more broadly in the Greenvale/Oaklands Junction area, and which ultimately led to the discovery of additional populations in the local area. This fact was not stated within the report and should have been.

It was not the authors' intention to deliberately leave Mr Faithfull out of the acknowledgements section or the body of the paper, nor was it the author's intention to mislead the reader into thinking that Biosis Research was responsible for identifying every population identified in the paper.

Yours faithfully,
Daniel Gilmore
Senior Zoologist
Biosis Research Pty Ltd

Dear Editor,

In your June 2008 edition of the Victorian Naturalist you published a book review written by University of Melbourne Associate Professor Brian Finlayson, which contained negative commentary about the Forest Practices Board (now known as the Forest Practices Authority), which he described as a 'tame watchdog' and 'morally and scientifically bankrupt'.

A long-standing tradition and principle in the scientific community is that scientists should not attempt to discredit the reputation of other scientists or organisations by publishing unsubstantiated slurs on their reputations. For example, the American Association of Petroleum Geologists' Code of Ethics states that 'members shall not falsely or maliciously attempt to injure the reputation or business of others' and 'members shall not make false, misleading, or unwarranted statements, representations or claims in regard to professional matters'. The Royal Society of New Zealand Code of Ethics requires that scientists should 'avoid falsely, vexatiously or maliciously attempting to impugn the reputations of colleagues'. Clearly Dr Finlayson is unaware of these standards.

University of Yale research[1] has found that the Tasmanian forest practices system is among the most prescriptive in the world, which gives the lie to claims that the forest industry in Tasmania is a 'tame watchdog'. The Forest Practices Authority provides independent advice and conducts independent audits and research relating to the continued improvement of forest practices in Tasmania and is one of the premier forest research organisations in the state: over the last ten years it has published numerous reports on forest-related issues. In this time it has also published more than 50 papers in peer-reviewed journals, both in Australia and internationally and the independence of its scientists is demonstrated by the fact none of these was vetted by the forest industry prior to being submitted for publication.

By any measure Dr Finlayson's derogatory remarks about the Forest Practices Authority are unprofessional. They reflect badly on him, the University of Melbourne, and *The Victorian Naturalist*.

The remarks reflect badly on Dr Finlayson because a person of his standing should be able to separate facts from political beliefs, and be aware of the ethical standards required of a senior member of a university department. They reflect badly on the University of Melbourne because, by signing over the University of Melbourne address, Dr Finlayson implies that his views represent those of the University. They reflect badly on the Victorian Naturalist, because this magazine prides itself on presenting informative factual science and this venture into the partisan political arena lowers the scientific standing of the publication.

I suggest that the editor of *The Victorian*

Naturalist should, as a minimum response, make clear that Dr Finlayson's views are not those of *The Victorian Naturalist*, and that Dr Finlayson should apologise to the scientific staff of the Forest Practices Authority for making unsubstantiated allegations about their moral status and scientific integrity, and make clear that the opinions he expressed are his own and do not represent those of the University of Melbourne.

Yours sincerely,

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Forest Practices Authority
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4 July 2008

1. http://www.yale.edu/forestcertification/Tasmania%20Report%20Final%20rev%20Feb%2008.pdf

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Reply to Dr Peter McIntosh's letter

Let's begin by clearing up one of Dr McIntosh's misconceptions. It is an established practice that academics at Australian Universities are free to express opinions on matters pertaining to their disciplines and to identify themselves as University staff. Such statements do not represent the views of the University.

I agree that the remarks made in my book review were expressed in intemperate language, but I stand by the contention that they were meant to convey. What I said there was not based on any political views I may hold, but on my experience in representing the Tasmanian Environmental Defender's Office in a court contest with Forestry Tasmania, and in visits I made to the north east of Tasmania to see forest practices being carried out there by Forestry Tasmania that had presumably been approved by the Forest Practices Authority.

Space here does not permit me to elaborate in detail on the evidence that supports my point of view. I have, however, written in more detail to the Chairman of the Forest Practices Authority. Here, I will present just one piece of that evidence. Dr McIntosh claims that 'the Tasmanian forest practices system is among the most prescriptive in the world'. In the photograph below the two people are standing in the bed of a Class 3 stream in a Forestry Tasmania logging coupe at Mt Arthur where, under the prescriptions of the Tasmanian forest practices code, there should be a buffer zone. I could fill the rest of this issue of *The Victorian Naturalist* with similar cases. I'll bet that the 50+ papers the staff of the Forest Practices Authority have published in peer-reviewed journals carefully avoid descriptions of these logging practices.

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